Closeout report for Denali Commission Grant #1461

Emerging Energy Technology Fund Data Collection

Alaska Energy Authority
March 31, 2020

Grant Purpose and Overview

AEA administered the Emerging Energy Technology Fund grant program from 2010 until January 1, 2020, when the program's statutory authority lapsed. The Alaska State Legislature created the Emerging Energy Technology Fund (EETF) in 2010 to promote the expansion of energy sources available to Alaskans. EETF grants are for demonstration projects of technologies that have a reasonable expectation of becoming commercially viable within five years. Projects can

- Test emerging energy technologies or methods of conserving energy;
- Improve an existing technology; or
- Deploy an existing technology that has not previously been demonstrated in the state.

The Denali Commission provided several grants to fund various aspects of the EETF: program administration, project funding, and third party verification.

Because the EETF's purpose was to test the efficacy of new technologies in Alaska, collecting and analyzing project data was seen as key to understanding the effectiveness of the technologies. The Denali Commission's grant allowed AEA to conduct third party verification of four Round 2 EETF projects.

To fulfill the requirements of this grant, AEA entered into a Reimbursable Service Agreement (RSA) with the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks (RSA #1610). Under this RSA, ACEP developed a data plan, collected data, and analyzed data for four EETF projects:

1. St. Paul Flywheel Demonstration, TDX
2. Multi-Stage Energy Storage System, Chugach Electric Association
3. Trans-Critical CO2 Heat Pump, Alaska Sea Life Center
4. Air Source Heat Pump, CCHRC

Results

Per the terms of the RSA, ACEP provided AEA with data plans and quarterly progress reports for each project. The ACEP progress reports were included with AEA's quarterly progress reports to the Denali Commission. Unlike in Round 1, ACEP was not required to provide full reports of the activities, although AEA did receive one full report from ACEP for Chugach Electric's Multi-Stage Energy Storage System. All of these progress reports and the CEA report were submitted to the Denali Commission at the appropriate time.

For each project, ACEP developed a data instrumentation and collection plan, collected data remotely and had it sent to ACEP's database, and provided analysis of the data.

The raw data collected from these four project is being stored by ACEP. Based on the progress reports, ACEP gathered multiple gigabytes of data from the four projects. AEA does not currently have the IT capability to adequately store the data.

St. Paul Flywheel Demonstration, TDX

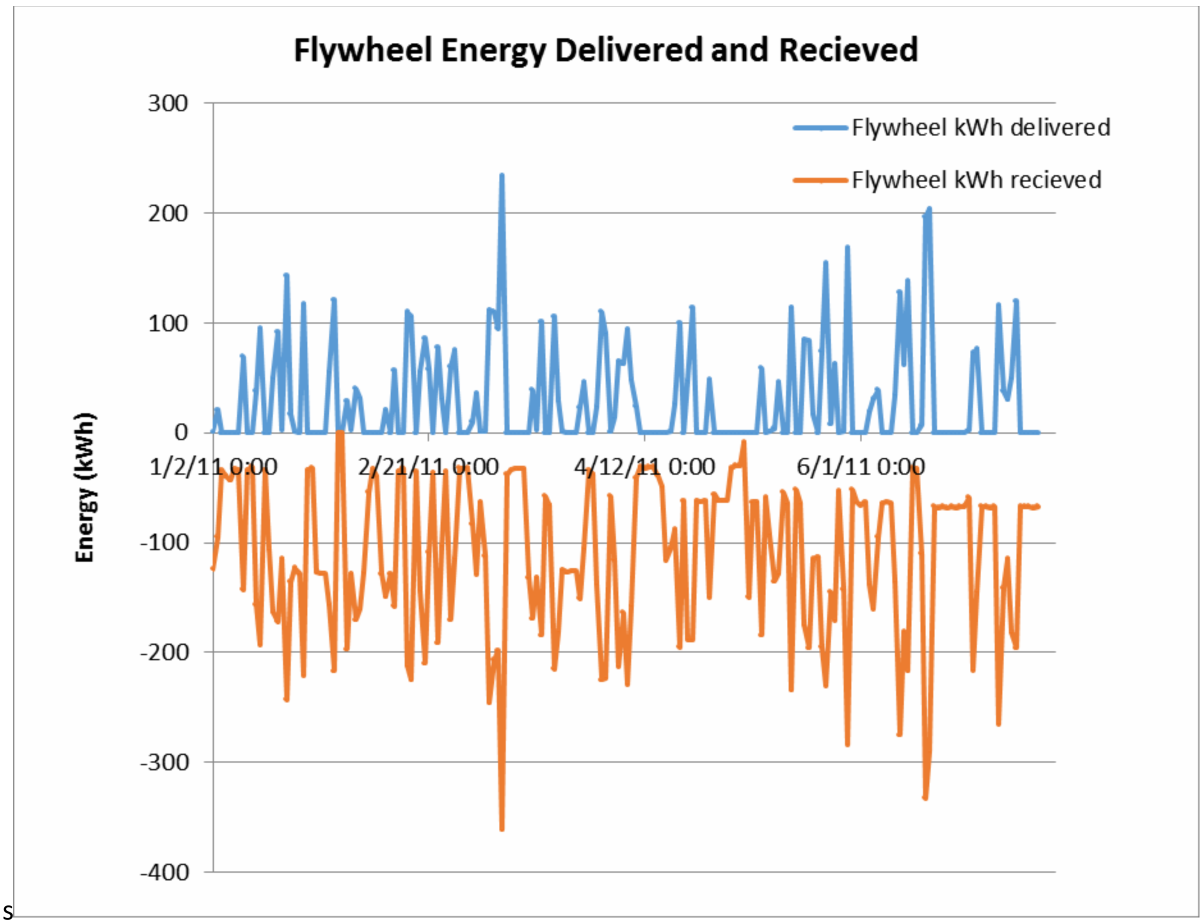
Purpose

This project has the primary goal of evaluating the market potential of flywheels in a rural setting.

Results

ACEP set up data collection and transfer system in 3rd quarter of 2014. The flywheel system was installed in the 4th quarter of 2014 and data was received starting November 19, 2014. In the first six months, more than 2 GB of data was transferred to ACEP.

The figure below shows the comparison between charge and discharge of the flywheel. As ACEP reported, summing the total energy delivered and received over this time period shows that the flywheel is approximately 27% efficient. As the flywheel is primarily of use when there is excess wind, efficiency is less of a concern. However, during periods of 100% diesel, and as flywheel systems get larger, the parasitic loss may be an issue and controls schemes that minimize flywheel charging during diesel operation may become desirable.



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The project operated for approximately 14 months. A bearing failure killed the project on 1/23/2016. The data collected by ACEP did not assist in determining a cause of the failure. Multiple potential points of failure were noted, but no definitive cause was reported by ACEP or the grantee.

TDX decided to not continue with operation of the flywheel because of the uncertainty of repeat failures and uncertainty of operational benefits.

Based on reports from the grantee, the flywheel was effective in reducing diesel consumption, but the reports from ACEP do not investigate or evaluate the overall effectiveness of the installation.

Multi-Stage Energy Storage System, Chugach Electric Association

Purpose

The primary goal of Chugach Electric Association's project was to determine if an energy storage system consisting of flywheels and lithium-ion batteries would smooth the integration of additional wind power from Fire Island, or other large-scale intermittent renewable energy sources, into Chugach's grid.

Results

The grant activities took significant time to start. From the records available to the current EETF program manager, AEA did not receive any progress reports on grant activities from ACEP. AEA received a detailed report from ACEP in June 2019.

CEA installed a 1-MW flywheel and 2-MW battery. Based on the data collected by ACEP, the flywheel was the primary source of power for the system. As seen in the charts below, the activity of the flywheel was frequent and worked to smooth out the variation in the wind output.

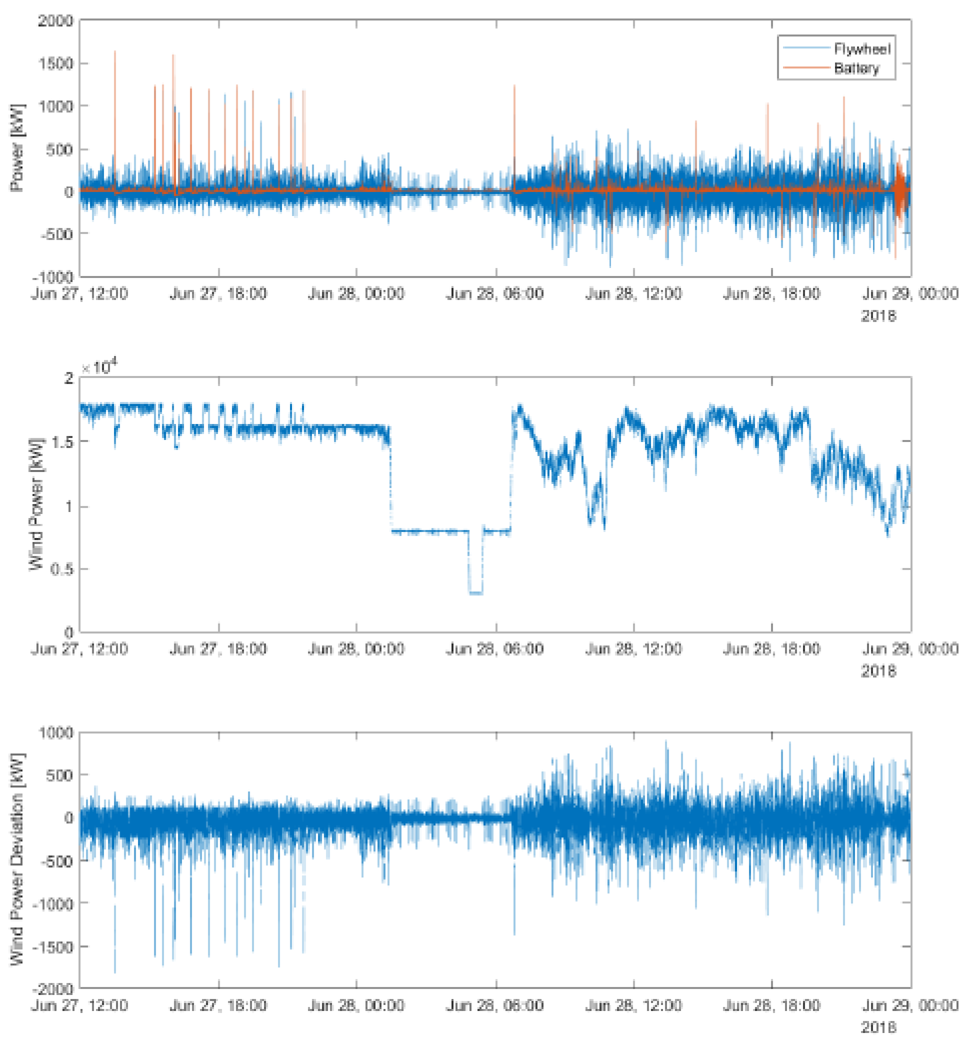


Figure 2: Data where ramp rate regulation was the only active control state other than recharge. The top plot shows the EESS power. The middle plot shows the wind farm power. The bottom plot shows the deviation in the uncompensated wind power from a 2.5 MW/min maximum ramp rate.

Interestingly, the flywheel and battery were needed only in cases of quick decreases in wind power, and not in rapid instances of wind ramping up.

ACEP provided very detailed data collection and analysis of specific control sequencing at the request of CEA. These controls

On a daily basis the flywheel averaged 140 cycles per day and the battery 0.3 cycles per day.

Table 11: Distribution and frequency of battery and flywheel power levels.

Parameter	Battery	Flywheel
Mean abs. power [kW]	16	54
90th prctl. abs. power [kW]	23	131
99th prctl. abs. power [kW]	129	386
99.9th prctl. abs. power [kW]	461	653
Abs. power > 500 kW [events/day]	5.6	26
Abs. power > 900 kW [events/day]	1.8	1.7
Abs. power > 1500 kW [events/day]	0.24	0
Abs. power > 1900 kW [events/day]	0.06	0

ACEP's analysis suggests that an expansion of Fire Island may require additional capacity of the flywheel and/or battery. ACEP is continuing to provide CEA analysis for this installation CEA, but not under the auspices of the EETF.

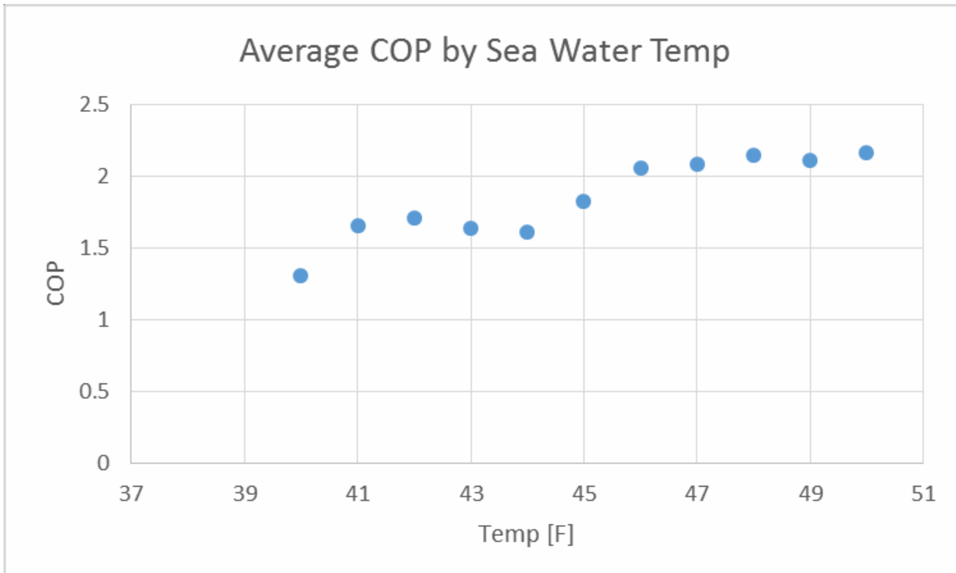
Trans-Critical CO_2 Heat Pump, Alaska Sea Life Center

Purpose

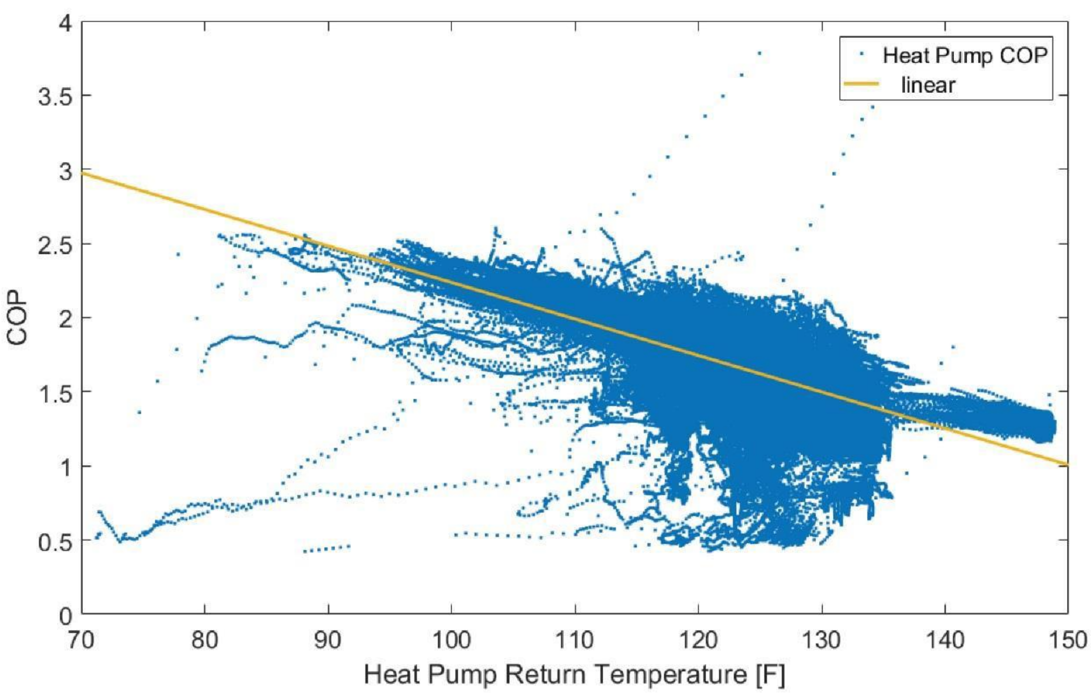
This project has the primary goal of evaluating the market potential of this trans-critical CO_2 heat pump system to offset and ultimately replace the use of oil boilers in cold climates.

Results

Effected by seawater temperature. Generally makes sense, but doesn't say if this was controlled for operational conditions.



Based on the chart below, the efficiency of the heat pump is directly affected by the return water temperature. At lower return water temperatures, the heat pump operates more efficiently. This is likely



due to a minimum loading required of the heat pump. Based on the availability of data shown in the chart, the extrapolated line below 90 degrees seem unwarranted based on the paucity of data. This trend warranted further testing as there might have been additional factors at lower temperatures that may have decreased efficiency.

Several cases of lost data due to a fouled flow meter paddle (Feb-March 2017) and a full database on the Tracer server (March 1-April 13, 2017). ACEP imputed some data points to correct for missing or incorrect data.

Overall, the CO_2 heat pump did not operate a high efficiency. It was well below the expected coefficient of performance of 3. Based on data supplied to AEA's REF program, the heat pump continues to have a low coefficient of performance. On average it has a COP below 2. ACEP's monitoring and reporting does not provide any analysis on what factors have led to the underperformance of the project.

Air-Source Heat Pump, Cold Climate Housing Research Center

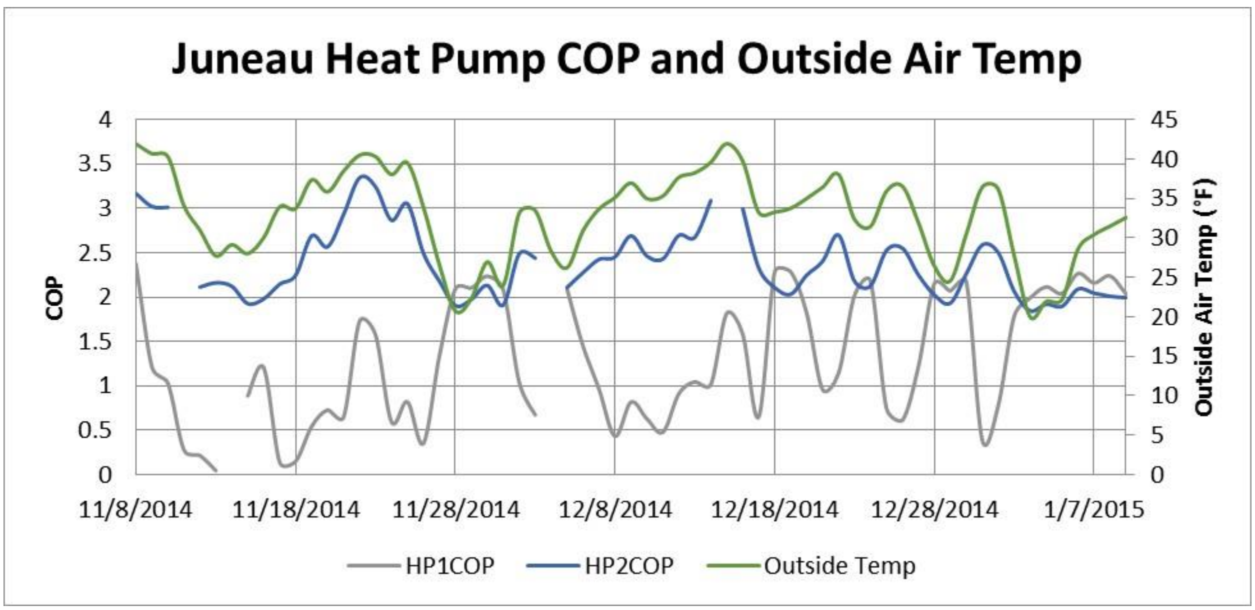
Purpose

The Cold Climate Housing Research Center (CCHRC) was the project lead. The project's primary goal was evaluating the market potential of air-source heat pumps (ASHPs) in Alaska by monitoring three ASHPs in Dillingham, Wrangell and Juneau. The City of Wrangell had an additional project goal of testing if replacing residential resistance heat with ASHPs could reduce utility demand by 2 MWs.

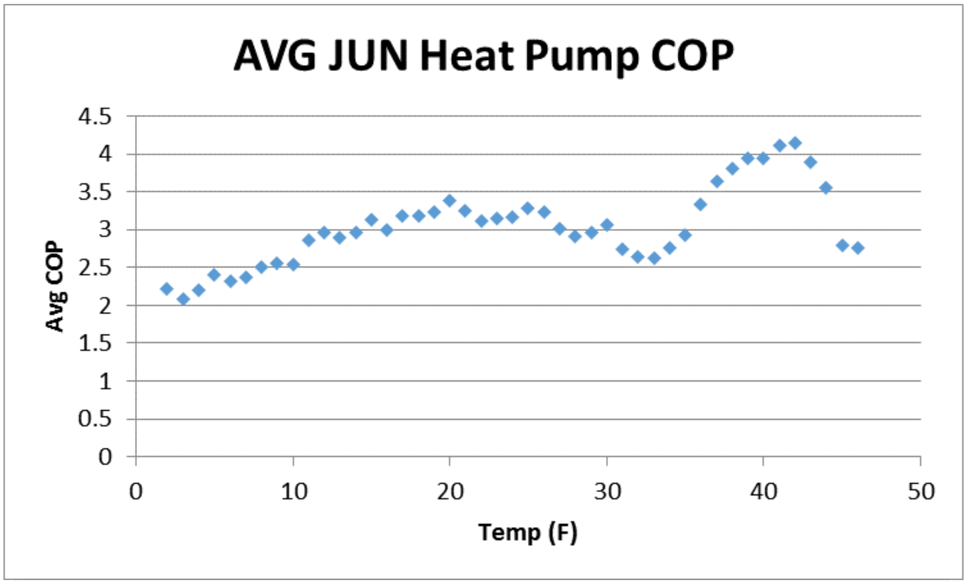
Results

Based on the grant closeout report to AEA from CCHRC, ACEP monitored three cold climate air-source heat pumps (ASHPs) over the winter of 2014–15. The three ASHPs located in Dillingham, Wrangell and Juneau, were monitored in detail to characterize their operational characteristics and efficiencies to determine how well they perform and whether they can be an effective tool for reducing peak electric power demand. A case study was performed for the community of Wrangell, Alaska to ascertain if installation of ASHPs could feasibly reduce overall utility demand by two megawatts. CCHRC also gathered general survey data for an additional 30 heat pumps installed in 10 different communities in Alaska and the Yukon Territory and evaluated through utility billing analysis and by interviewing building occupants about their satisfaction with the technology.

The installation in Juneau included two heat air-to-water heat pumps in a residence. One heat pump was used primarily for domestic hot water, except when the temperature dropped by 30 degrees. Some of the charts provided had confusing color choices which made trend analysis difficult. The chart below is an example of this.

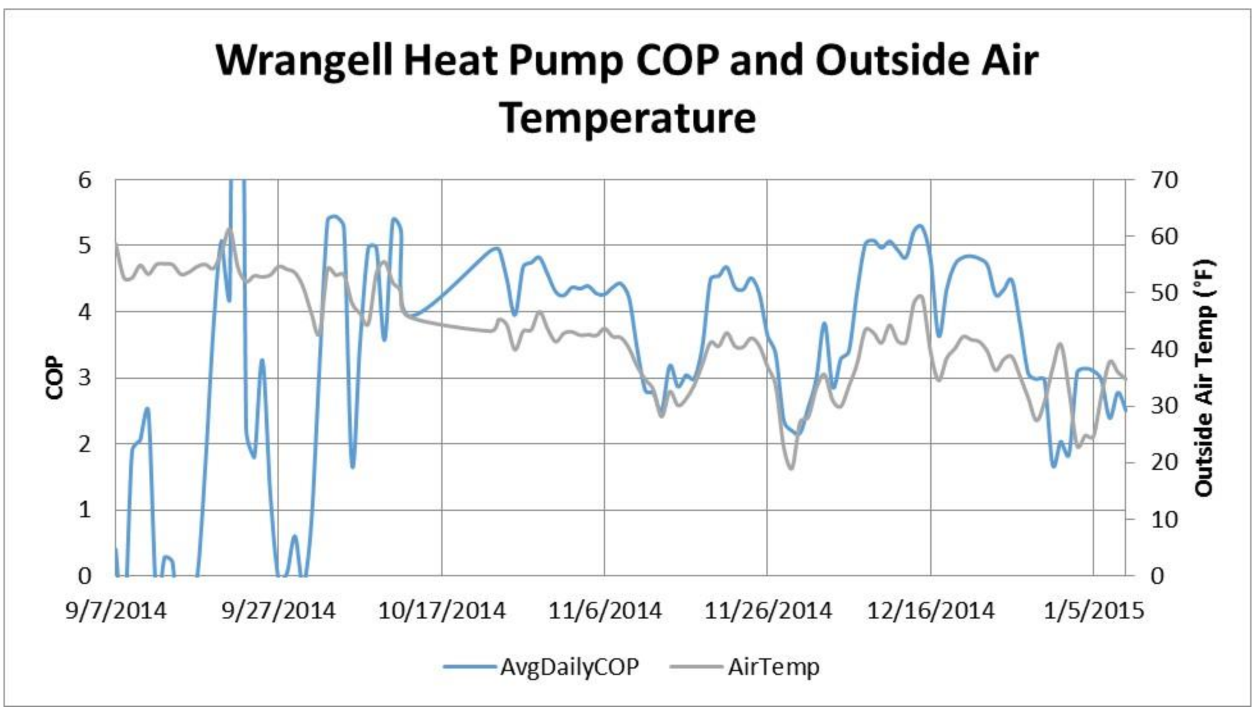


As expected, the data shows a strong correlation between outdoor temperature and heat pump efficiency. As the temperature decreases so does the efficiency. In general, the efficiency does not match the expected performance of the heat pump, although this analysis was not performed or at least not provided to AEA in progress reports.

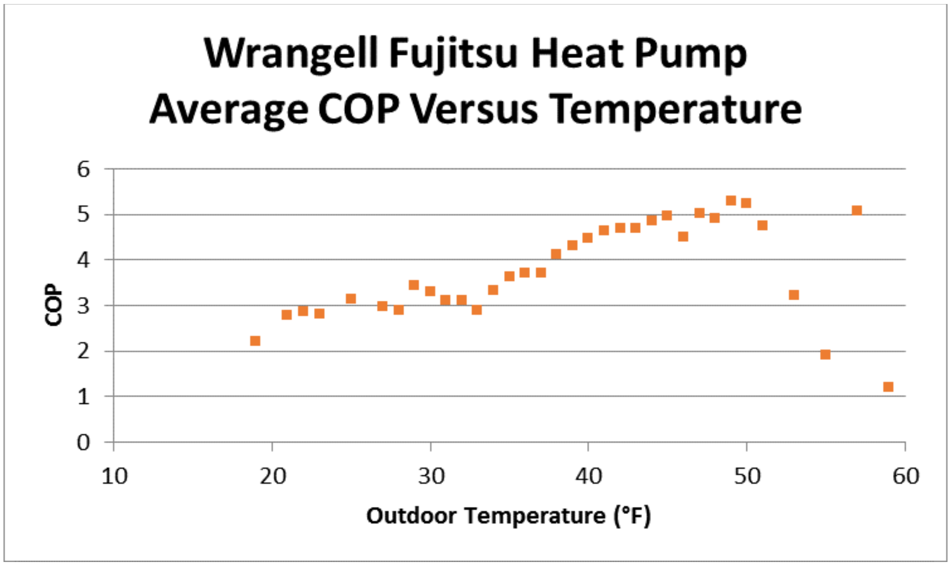


One air-to-air heat pump was installed in the Wrangell utility office building. Clay Hammer (the Wrangell utility manager) reported that due to the low grade heat produced, the heat pump takes a while to heat up the building. Consequently, the utility office leaves it set at 70 degrees Fahrenheit and does not turn it down at night. During colder parts of the year, the heat pump doesn't turn off. Because of these factors, it would be expected that the heat pump would be working at maximum efficiency as start-stop cycles would be limited.

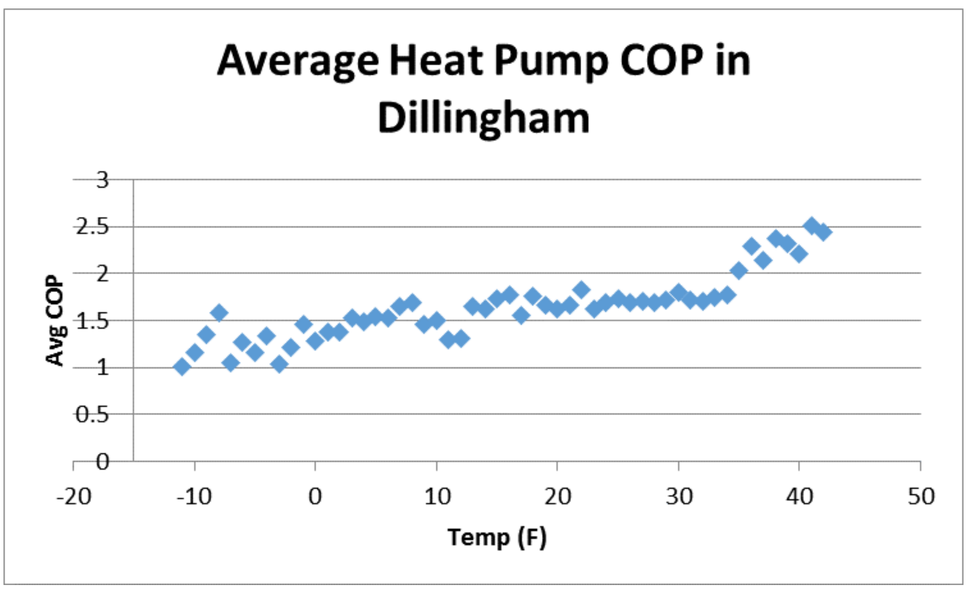
Data issues early in the data collection process made for inconsistent results, as seen in the first month in the following chart.



At relatively moderate temperatures, above 40 degrees, the ASHP performed with a high efficiency (COP>4), but below that the COP drops off. The efficiency is roughly consistent with the installation in Juneau, although the temperature range is more constrained in Wrangell.



The ASHP installation in Dillingham is in a high efficiency private residence. The COP, as seen in the chart below, was remarkably lower than the other installations.



As reported in the grant closeout report to AEA from CCHRC, several problems occurred in the detailed monitoring of the three ASHPs during the winter of 2014-15. "1) problems with data transfer at the Wrangell installation occurred in fall of 2014 and flow measurements were also compromised by calibration issues, which lead to all data collected before early December were ignored; 2) data collection at the Juneau installation was also affected by data logger issues, leading to data loss before late November; and 3) the outside air temperature sensor in Wrangell was occasionally affected by the sun, leading to higher recorded temperature readings than the air temperature."